Miniature High Efficiency Piezoelectric Motor

DARPA Smart Structures Technology Interchange Meeting

CHAP Kick-Off Meeting

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Creare

Objective and Scope

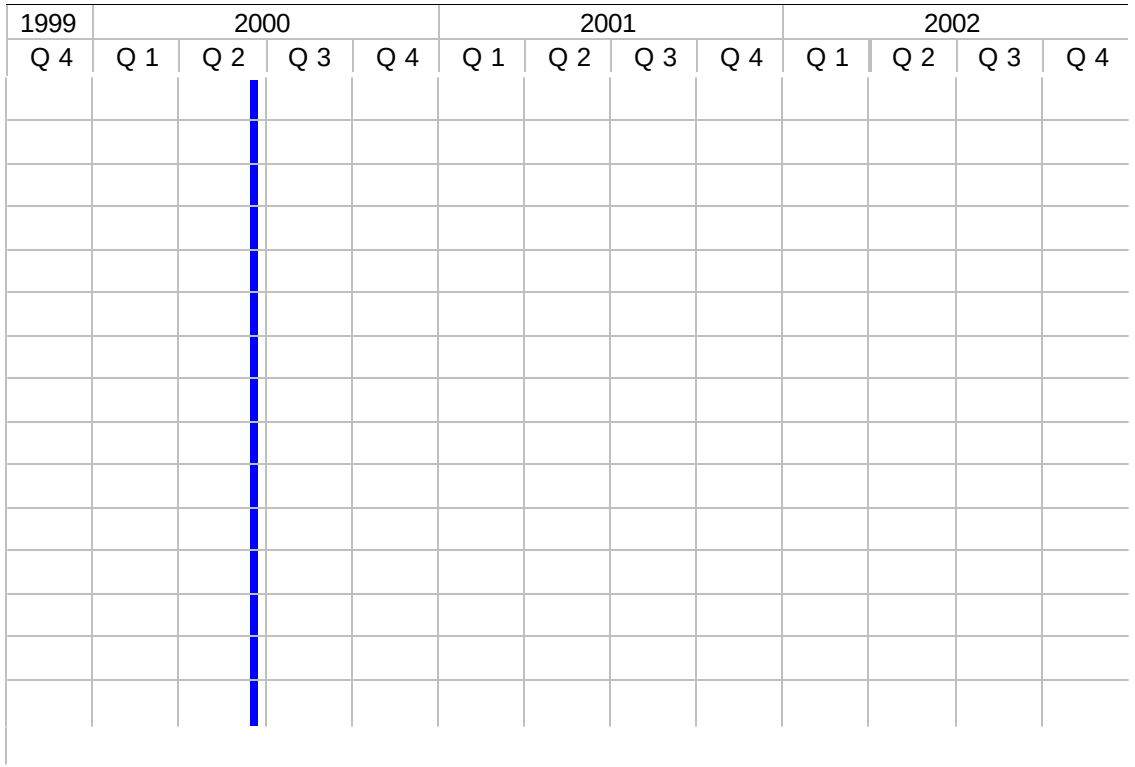
Program Objectives and Approach

- Convert electrical to mechanical power
- High efficiency and high power density
- Piezoelectric actuators in a novel motor configuration
- Electronic drive/control system for high efficiency

Scope

- Phase I: Prove feasibility
  - Demonstrate proof-of-concept motor
  - Demonstrate proof-of-concept drive/control system
- Phase II: Design, build, and test prototype motor
  - Develop high power motor (10 W) and drive/control system
  - Integrate and test high power motor
  - Package for final application
- Phase III: Production of piezo motors

Accomplishments and Remaining Work



- We have successfully demonstrated feasibility in Phase I
  - Mechanical system (complete mechanical motor assembly)
  - Drive/control system (efficient motor control, one phase)
- We will scale up the power and develop a prototypical package in Phase II

Project Team

Phases I and II: Prove Feasibility and Demonstrate Prototype

- Creare is the sole contractor for Phases I and II
- Experienced in development of piezoelectric devices, including valves, liquid pumps, and vacuum pumps
- Have all necessary expertise in mechanical and electrical system design and fabrication

Phases III: Manufacture Piezo Motors

- Creare will manufacture custom motors in small quantities
- May team to employ advanced actuator materials
- Will transfer technology as needed to satisfy demand for large quantities of piezo motors

Major Accomplishments

- Demonstrated mechanical drive feasibility
  - "Three phase" mechanical drive
  - Direct drive, no friction couplings
  - Generated 50 mW of mechanical power at 80 Hz rotating speed
- Demonstrated electronic drive feasibility
  - Efficient actuation of and power recovery from actuators
  - Compact components
  - Able to drive piezo motor from low voltage source
- Design for Phase II motor
  - Scaled up from the Phase I proof-of-concept unit
  - 10 W output power, 0.0075 N-m (1.1 oz-in.) torque, 100,000 RPM rotating speed

Gains and End Applications

- Advantages:
  - “Solid state” reliable drive system
  - High power output
  - Compact
  - High speed
  - Low-voltage power source
- End Applications:
  - Miniature turbomachines
    - Miniature vacuum pumps for portable mass spectrometers
  - Actuators for spacecraft
    - Adaptive optical surfaces

Miniature Vacuum Pumps

- Applications:
  - Chemical/biological weapons detection
  - Scientific instruments on spacecraft
  - atmospheric monitoring
  - ground pollution monitoring
  - medical diagnostics World's smallest and lightest turbomolecular vacuum pump
- Pump Characteristics:
  - Power consumption ~1 W
  - Maximum foreline pressure 10 mTorr
  - Pump speed > 4 L/s
  - Compression ratio (N_2) > 10^6
  - Design life: 1 yr continuous operation
- Motor Specifications:
  - High speed (~100,000 rpm)
  - Compact ("D-Cell" size)
  - Efficient
  - Long life (at least one year)

Creare's Miniature Turbomolecular Pump

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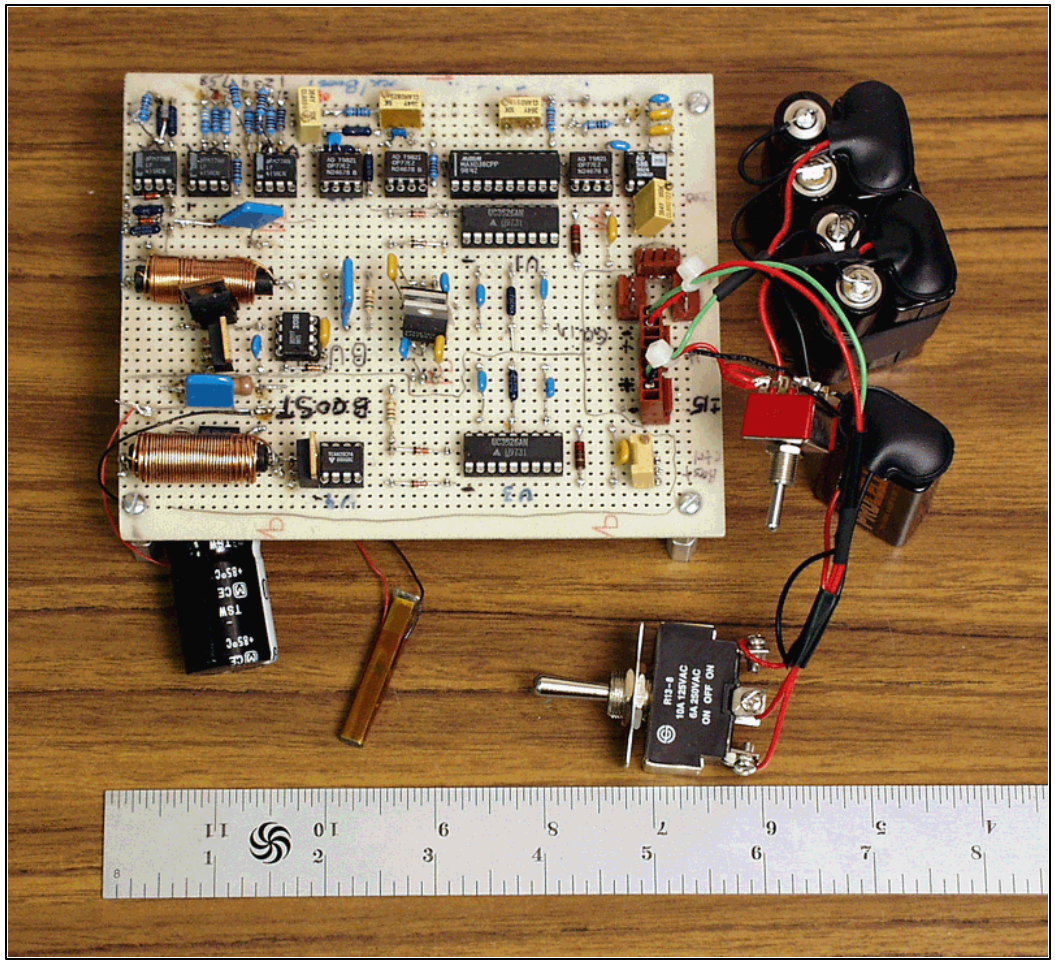
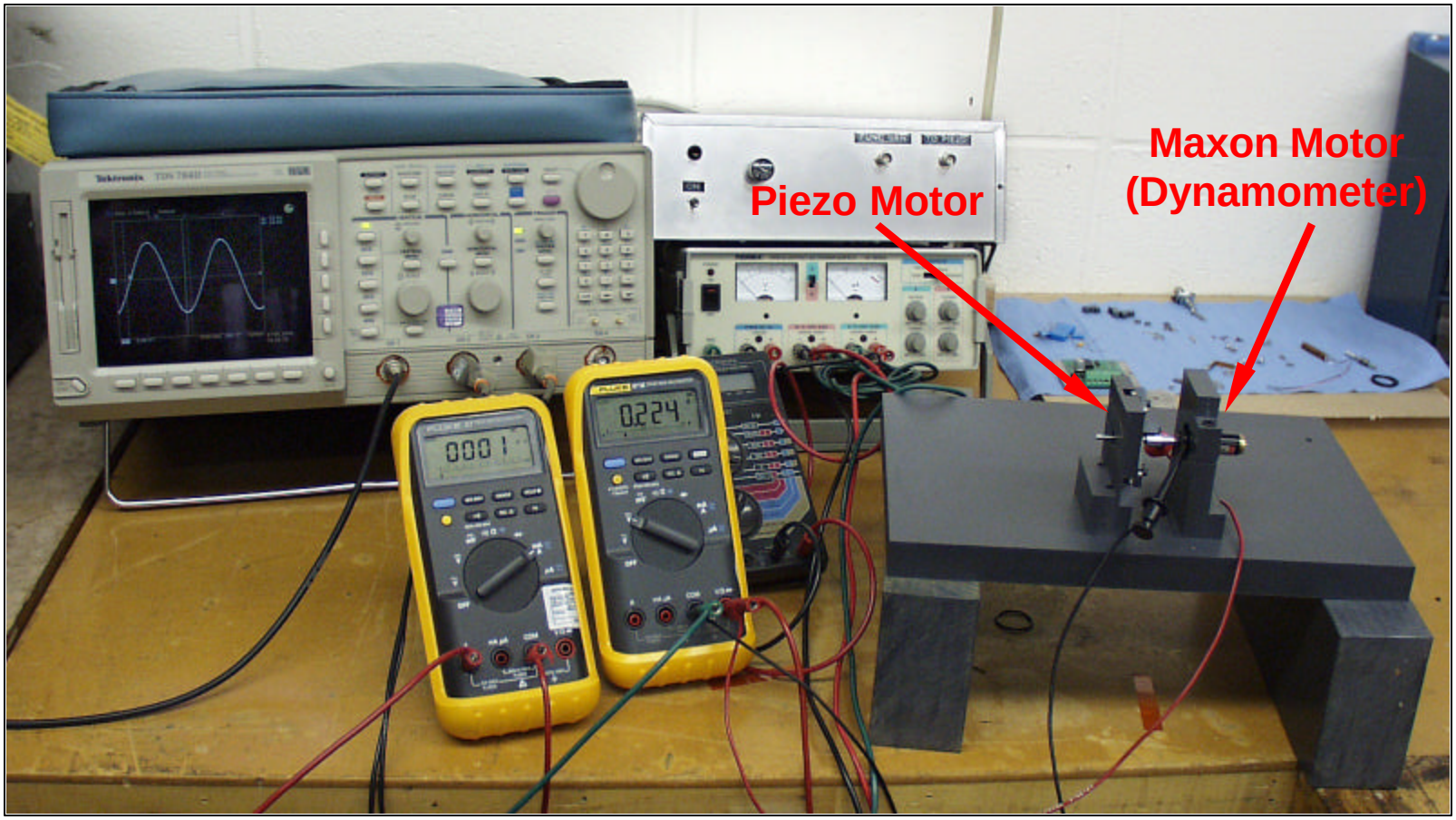
Power Supply and Control

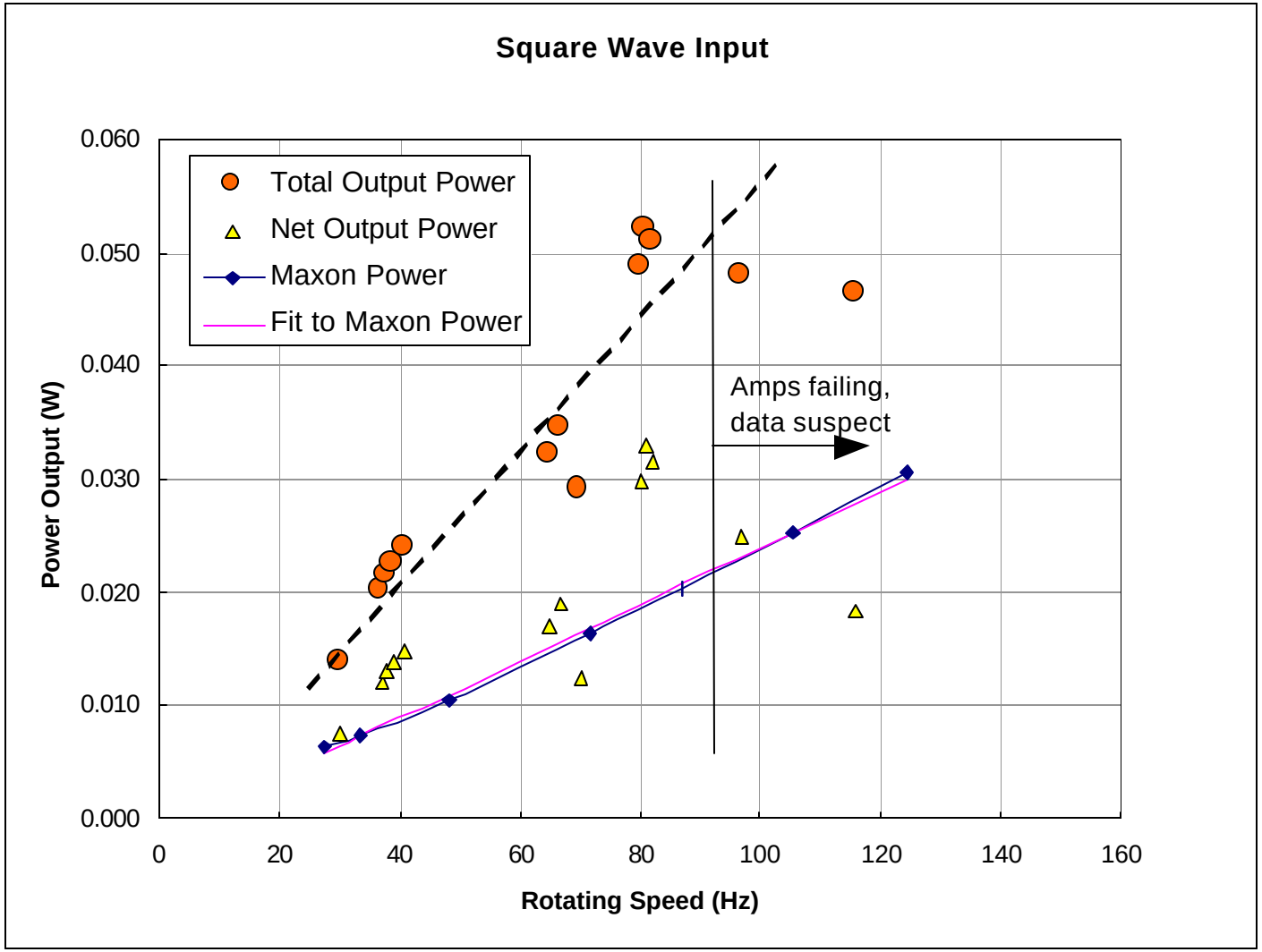
Prototype Photograph (Battery Powered)



Motor Test Setup



Motor Performance Data



Efficient Power Supply

Parameter	Linear amplifier control	Breadboard power supply
Electrical input power to drive (mW)	21,000	150
Electrical power to actuator (mW)	120	120
Actuator mechanical output power (mW)	20	20
Power delivered to load cell (mW)	18	18

- Breadboard unit (non-optimized components)
- Test conditions
  - Frequency: 235 Hz
  - Voltage: 24 V peak-to-peak w. 24 V offset